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CYLINDRICAL HOLOGRAMS FOR TARGET RECOGNITION TRAINING

Physical Sciences Laboratory
Naval Training Equipment Center
Orlando, Florida 32813

April 1977

Interim Report for Period July 1975 - June 1976

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NEIL MOHON
Physical Sciences Laboratory

April 1977

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

Techniques were developed for constructing cylindrically shaped holograms to be used to train the recognition of various military targets. In the past, a set of photographs was used to teach the target identification. Each photograph presented a different angular viewpoint of the target. The cylindrical format holograms provided a significant improvement over the previous methods by presenting a continuous view of the target through

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360° rotations. An infinite number of aspect views were effectively presented. A unique vacuum film holder was constructed to support the film in a stationary manner during exposure without distorting the flexible film. The gaussian power shape of the laser beam was used to compensate the $1/r^2$ — R square beam intensity falloff through the length of the film cylinder. The laser beam was circularly polarized to eliminate TE and TM polarization reflection differences around the cylindrically shaped film in accordance with the Fresnel equations. The resulting holograms were evaluated in terms of the proposed application to target recognition training. Alternate film configurations were proposed and experimentally evaluated.

PREFACE

The work described in this report was performed in-house in the Physical Sciences Laboratory at the Naval Training Equipment Center. The Physical Sciences Lab has as its mission in part to conduct research into displays and simulation devices which use optical, laser, holographic, infrared, electro-optical, and photographic techniques to represent the environment as "seen" by instrumental and/or visual sensors. Working under the guidance of this mission, the application of cylindrical holograms to target recognition was pursued resulting in a novel means for carrying out one of the training requirements in the Navy and other services.

ALFRED RODEMANN

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SECTION I

INTRODUCTION

This report addresses the subject of target recognition training for military personnel. Recognition training is employed to teach spotters, gunners, field soldiers, etc., to rapidly identify approaching aircraft and make an immediate determination as to friend or foe. It is necessary for such personnel to be very familiar with views of the aircraft from all angles because a low flying craft may be traveling at several hundred miles per hour, thus allowing a very short time in which to decide whether or not to fire on the craft.

In the past (see figure 1) this training has been accomplished by providing the student with a series of photographs of a few, fixed, angular views, of many friendly and unfriendly aircraft which he would study for several hours. The student was then tested by having the same views flashed before him for a short period of time by an instructor. There were no new intermediate views introduced to determine the student's ability to correctly interpolate between views.

As an alternate (see figure 2) to this system, we proposed the use of cylindrical wraparound holograms of the aircraft which could be used to study the profile of the aircraft in a continuous manner. This system would overcome the gaps of information inherent in the previous method; and a student would not be required to interpolate at all. This method would also result in a reduction in the physical size of the storage library required to be transported to each location for the training sessions.

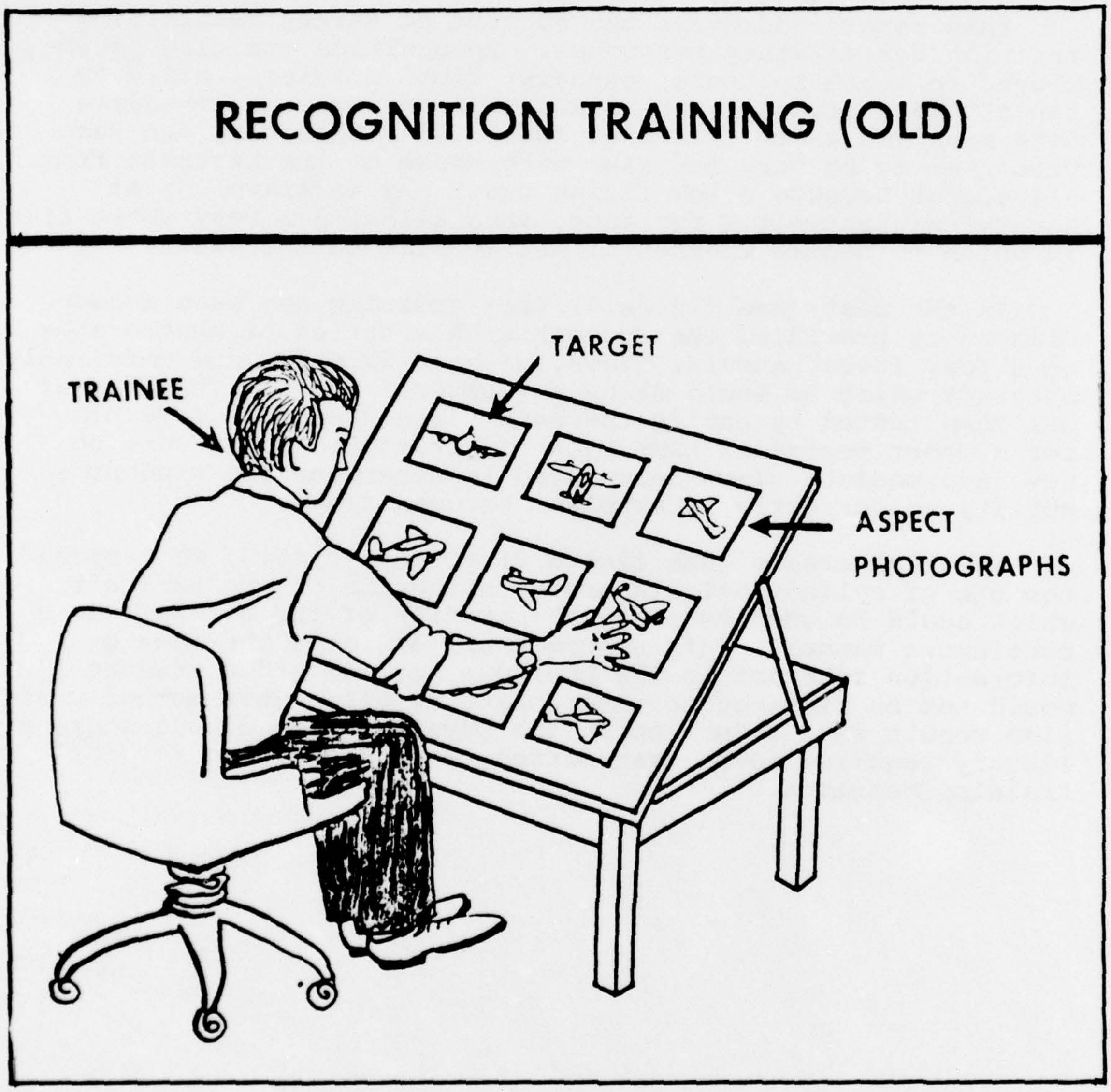

Figure 1. Recognition Training (old)

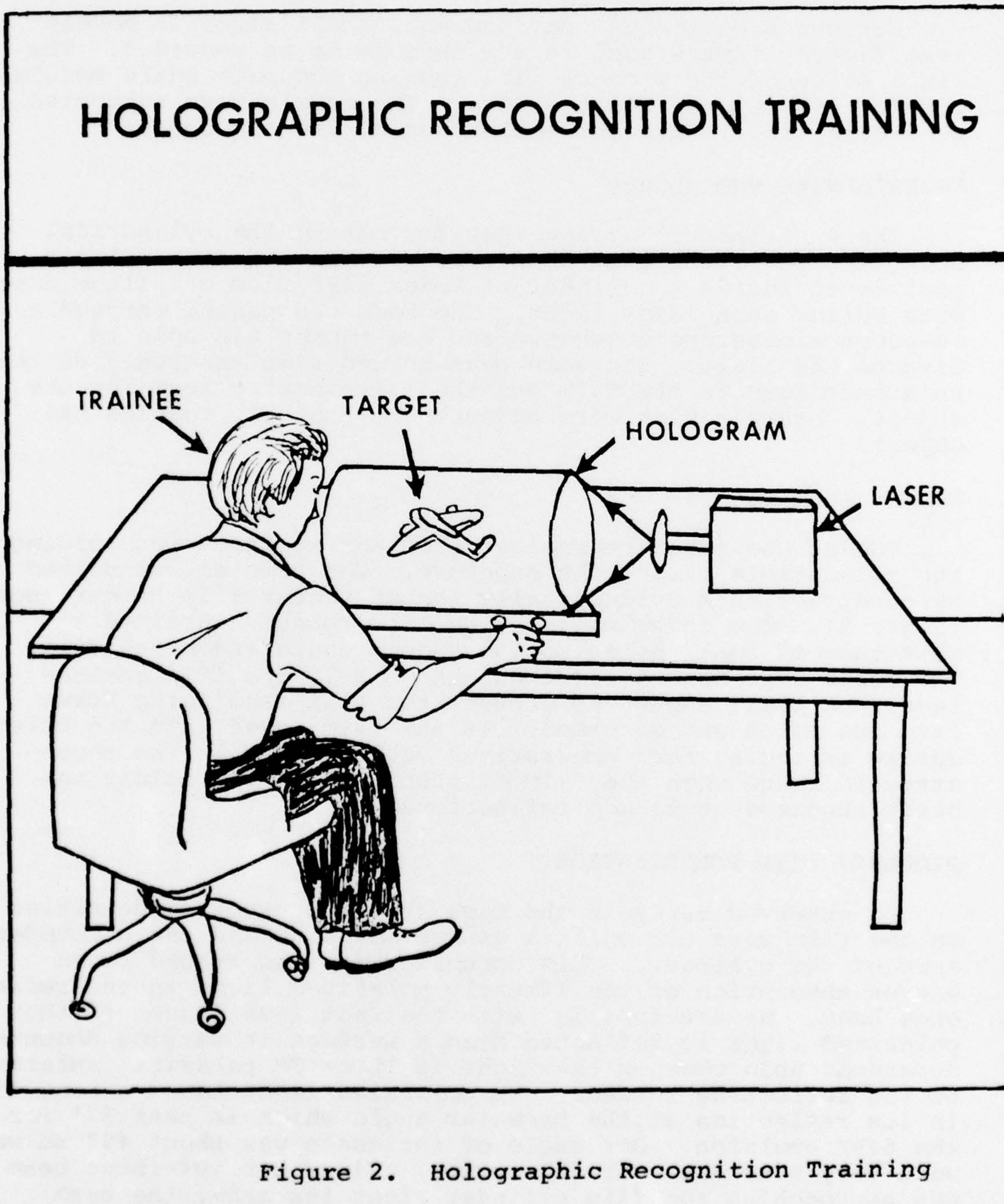

Figure 2. Holographic Recognition Training

SECTION II

CONSTRUCTION OF THE HOLOGRAM

For our experimental development, small aircraft models (see figure 3) were used as the objects to be recorded. The final phase of the project will require accurate scale models costing hundreds of dollars each. The models were supported by a metal rod to prevent motion during the exposures.

EXPERIMENTAL PROCEDURES

The experimental arrangement for making the cylindrical holograms is illustrated in figure 4. The object model was positioned inside a cylinder of Kodak 649F film and illuminated with helium neon laser light. The beam was passed through a 60-power microscope objective and one micron pin hole to diverge the light. The same beam served simultaneously as the reference beam to the film and the illuminating beam for the object. Beams ratios were adjusted by properly coating the object.

VACUUM FILM HOLDER

One of the major mechanical problems we faced was holding the film stable during the exposure. The problem was solved by constructing a cylindrically shaped vacuum film holder (see figure 5). The inner wall of the film holder contained a multitude of small holes so the vacuum could reach the film. The holes were spaced close enough to hold the film motionless, and small enough to prevent the film from being drawn into the holes and deformed. If the film caved into the holes during exposure, then aberrations would appear in the reconstructed image when the film flattened out. The holder was black anodized to reduce reflections.

PROBLEMS WITH POLARIZATION

We observed early in the task that the exposure densities on the film were not uniform as one moved around the circumference of the cylinder. This nonuniformity was traced to an uneven absorption of the linearly polarized light in the reference beam. We are familiar with the fact (see figure 6) that polarized light is reflected from a surface in varying amounts dependent upon whether the light is TE or TM polarized relative to the reflecting surface. TM polarized light has a strong dip in its reflection at the brewster angle which is near 57° for the 649F emulsion. Our angle of incidence was about 45° so we were very near the critical region. Since our reference beam was approaching the film cylinder along its axis, the beam appeared TE polarized at the top and bottom of the cylinder, TM

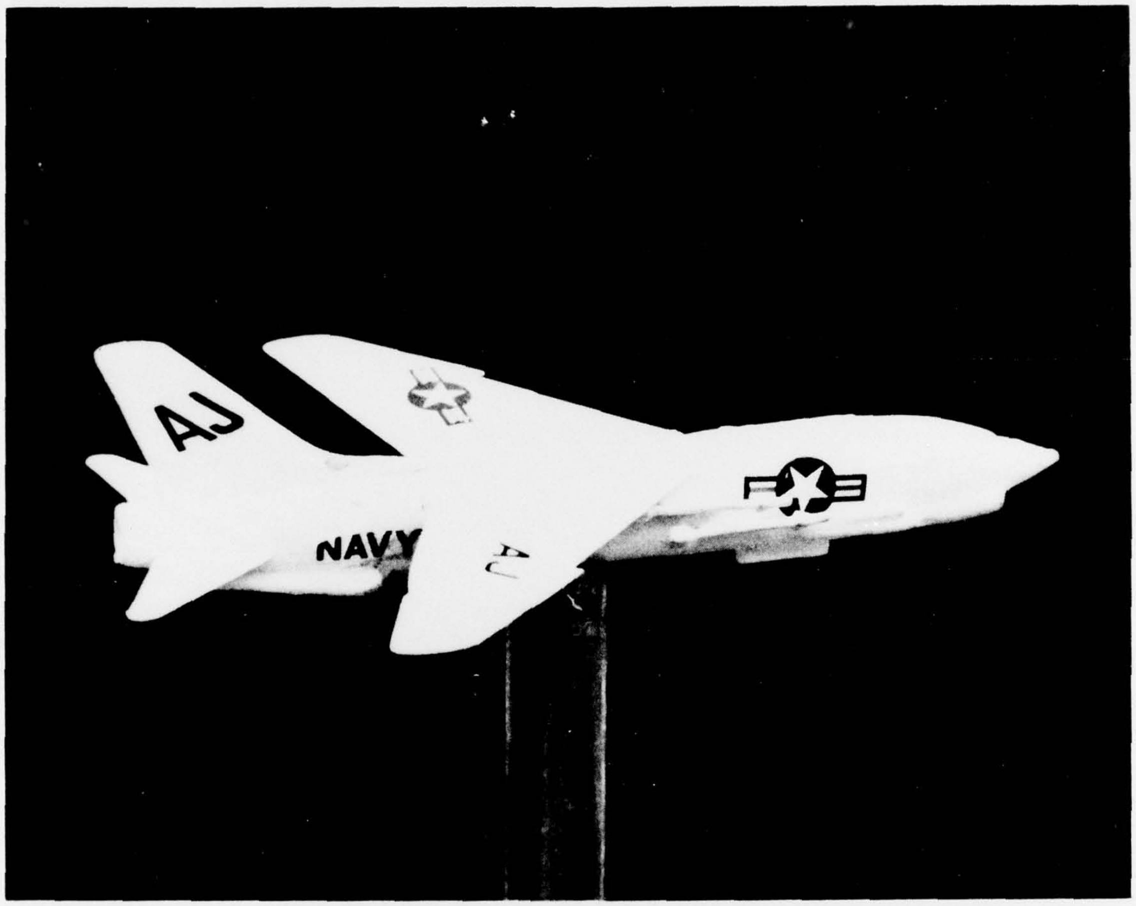

Figure 3. Aircraft Model

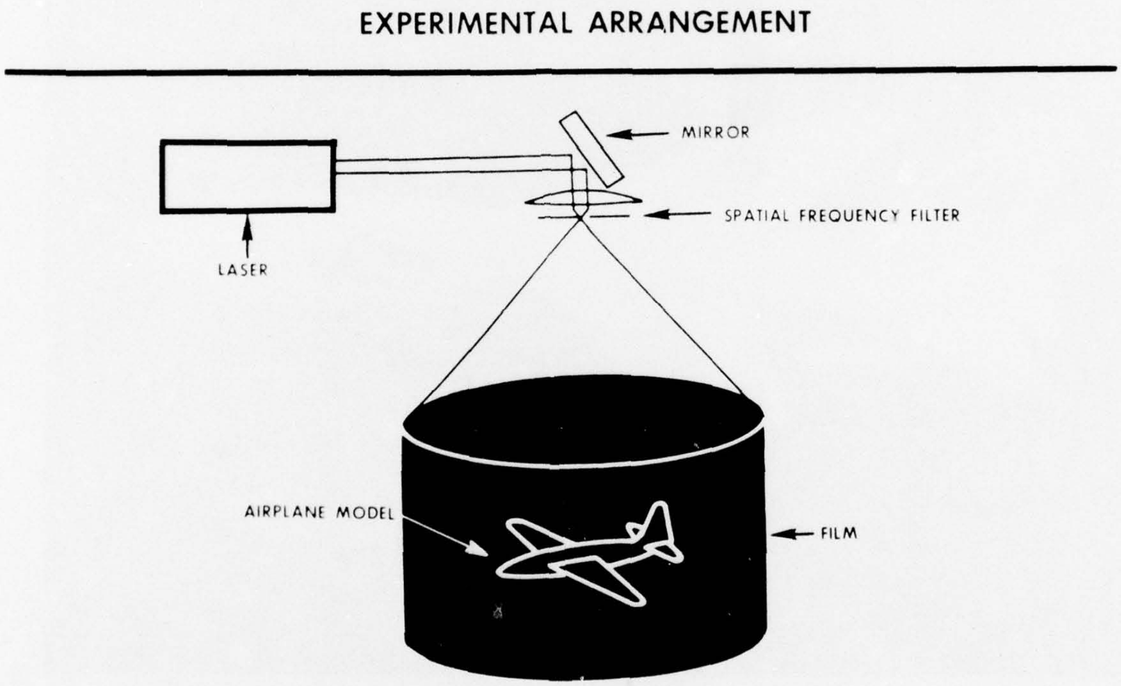

Figure 4. Experimental Arrangement

Figure 5. Vacuum Film Holder

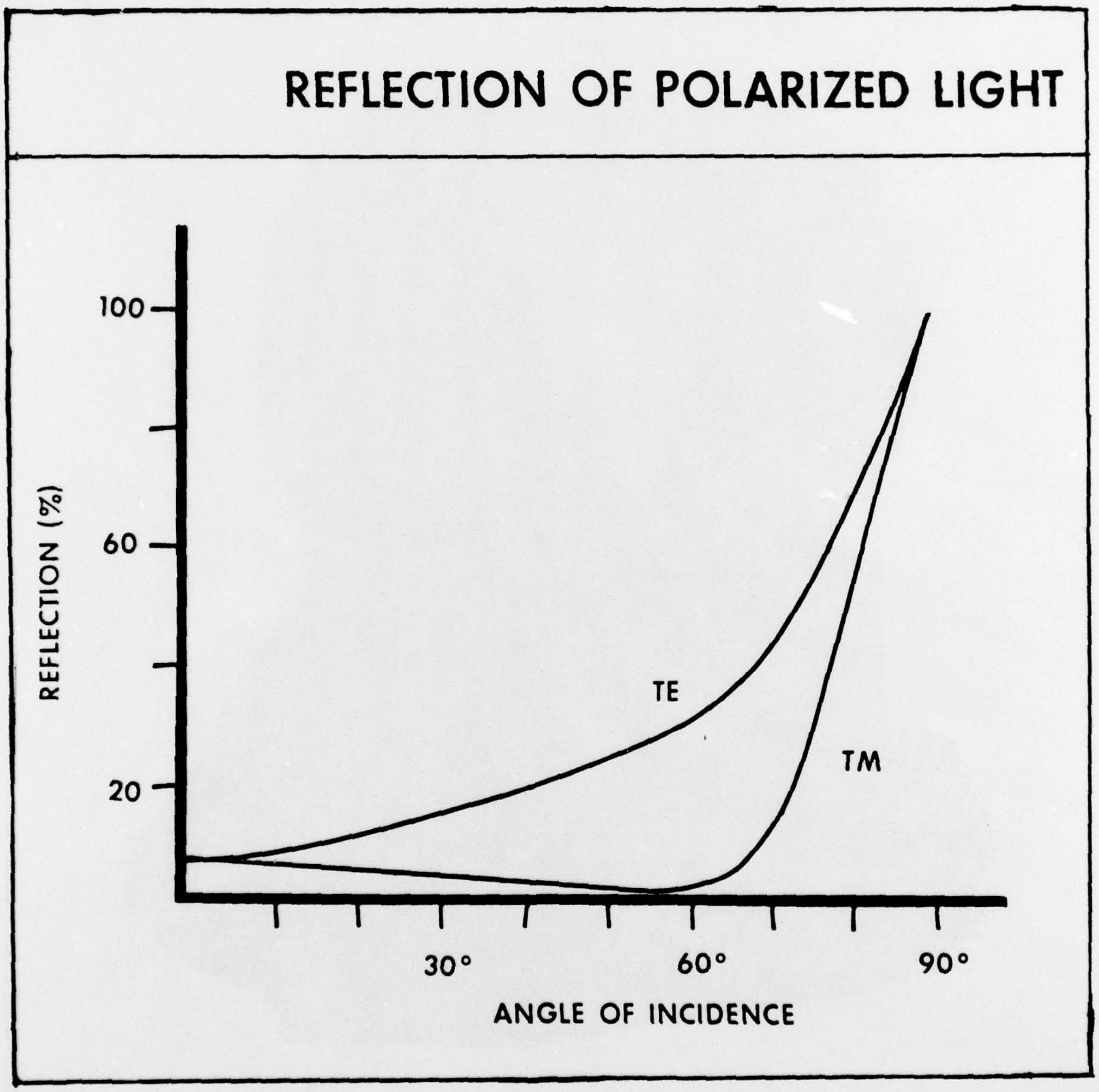

Figure 6. Reflection of Polarized Light

polarized at the sides, and somewhere between these extremes on other parts of the cylinder. Our solution (see figure 7) to this problem was to circularly polarize the reference beam by passing it through a properly oriented quarter wave plate. The laser beam was then polarized in the same manner all around the cylinder. Hence, the amount of reference beam light entering the film was not a function of angle around the cylinder and it produced an even exposure.

DISTANCE SQUARED LIGHT FALLOFF

Another unevenness in the density on the film occurred from the top to the bottom of the film cylinder. This irregularity was a function of the distance squared light falloff along the length of the cylinder. As shown in figure 8, the irradiance varied about 4 to 1 along the length of the cylinder. This problem was overcome by using the gaussian intensity shape of the laser beam to balance the $1/r^2$ irradiance falloff. The laser beam intensity was smaller near the outer extremity of the beam which impinged on the near end of the cylinder, and larger toward the center of the beam which impinged on the far end of the cylinder. The two parameters were carefully balanced to eliminate the variation in film exposure levels along the length of the cylinder walls.

HOLOGRAPHIC DISPLAY

For display and use, the holograms were mounted (see figure 9) inside a clear plastic tube and illuminated with a helium neon laser. A trainee is permitted to rotate the cylinder freely and study all aspect views of the aircraft. He may quickly remove the first hologram and insert a second in order to study a second type of aircraft. Instructor testing can quickly yield a high level of proficiency and confidence in the student. Previous training methods did not provide the infinite number of continuous views provided by the hologram. Alternate film configurations, such as the one shown in figure 12, were constructed and analyzed, but appeared to offer no advantages over the cylindrically shaped holograms.

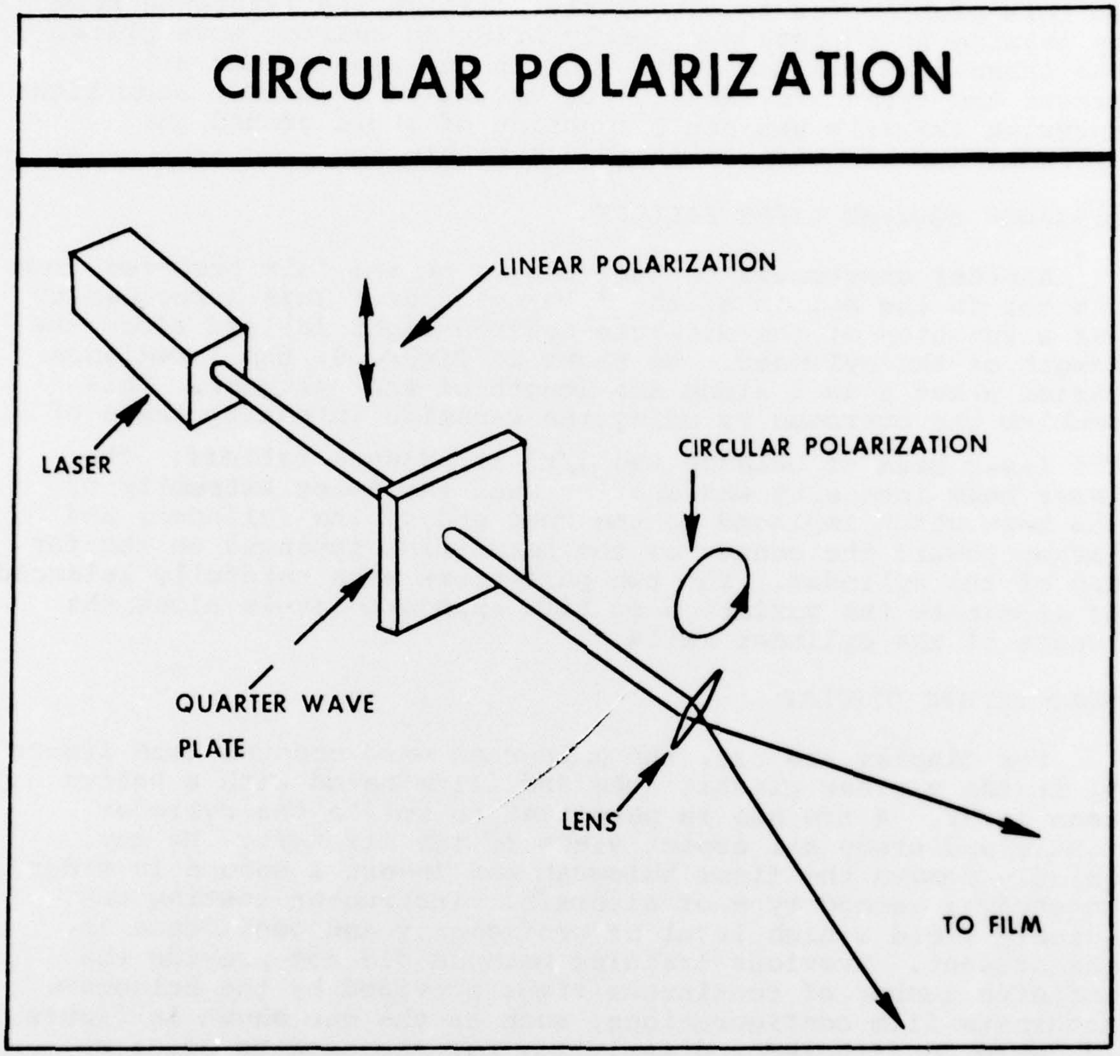

Figure 7. Circular Polarization

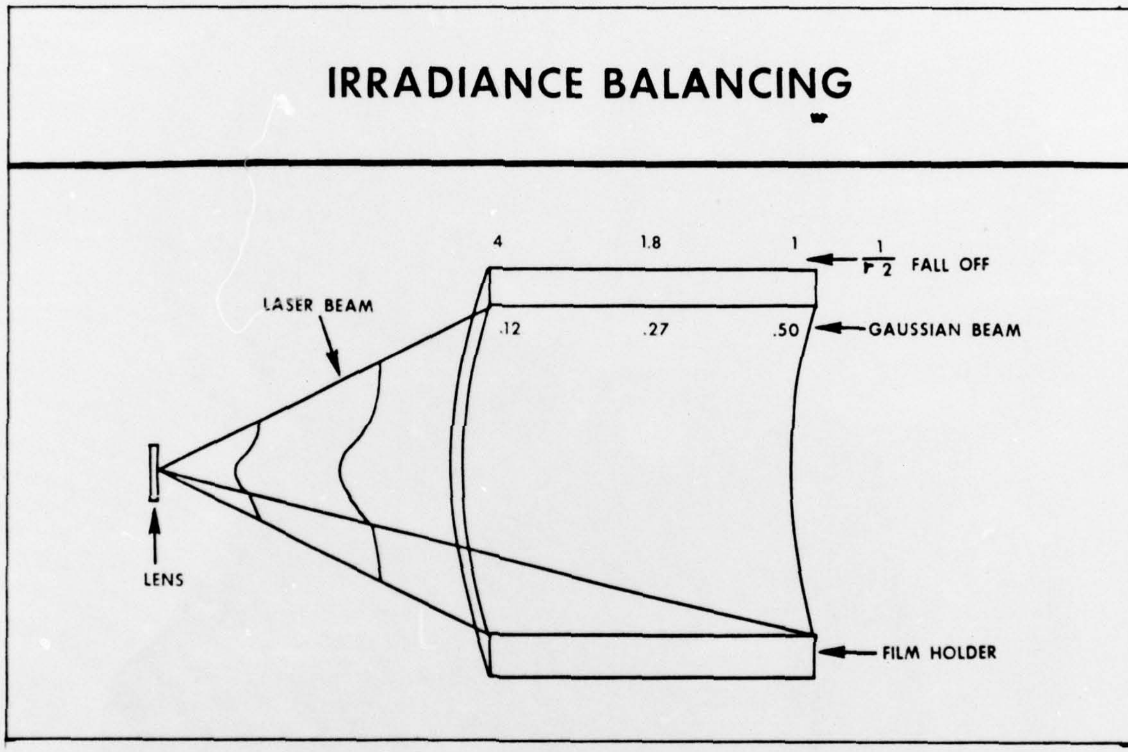

Figure 8. Irradiance Balancing

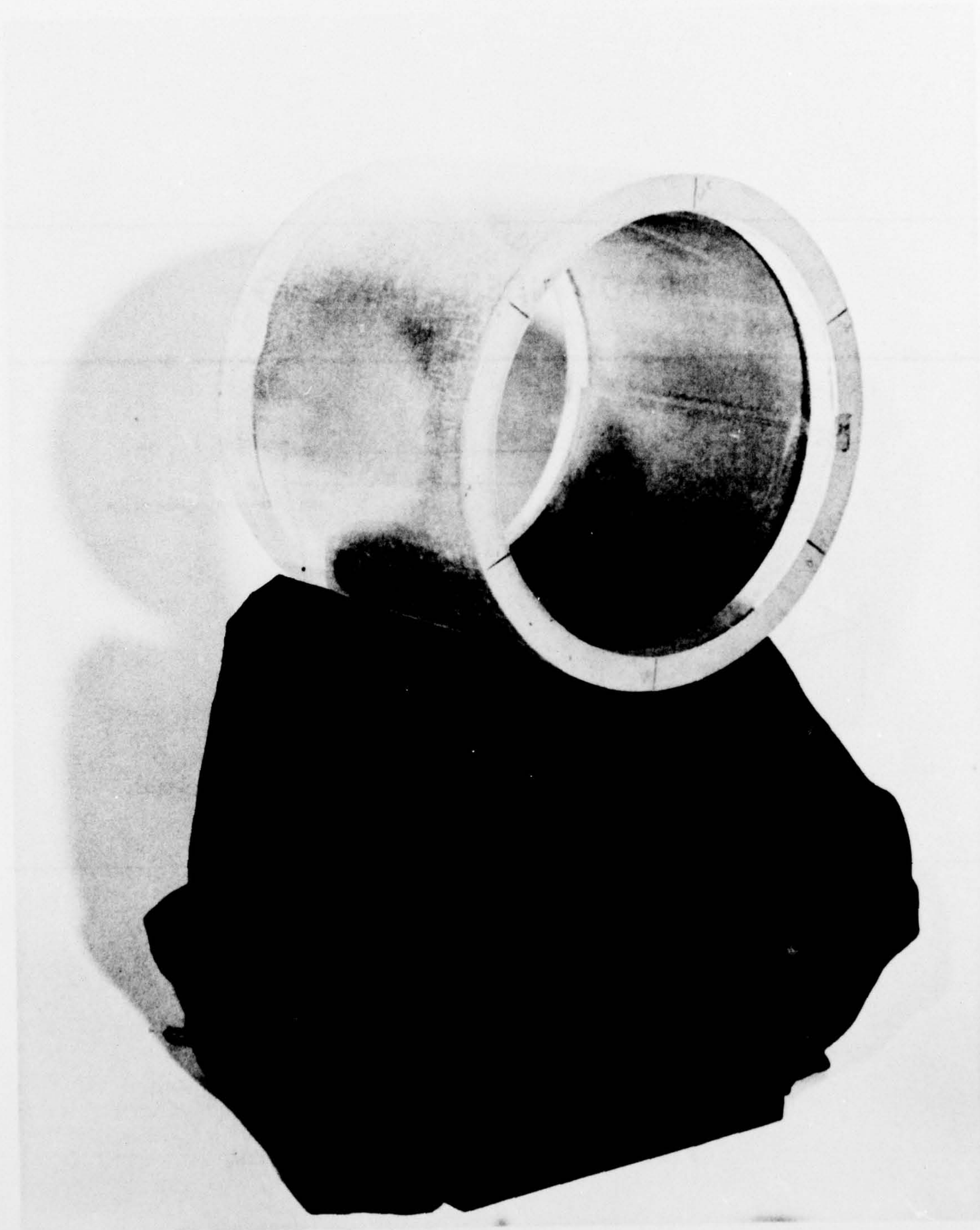

Figure 9. Holographic Display

SECTION III

RESULTS

Figures 10 and 11 illustrate one example of the cylindrical holograms produced. Here the images are enlarged 15 times so there is considerable degradation in image quality. However, you should be able to get a general impression of the results.

The cylindrical holograms provided at least one completely new feature over previous methods of target recognition training by allowing the student to study an infinite number of aspect views in a continuous manner. There was a slight reduction in cost per aircraft in the storage library; and a considerable reduction in the physical volume required for each library station.

My colleagues in this work were Alfred H. Rodemann, who served as Project Leader, and Denis R. Breglia, my Associate Investigator. This work was funded by the Naval Air Systems Command.

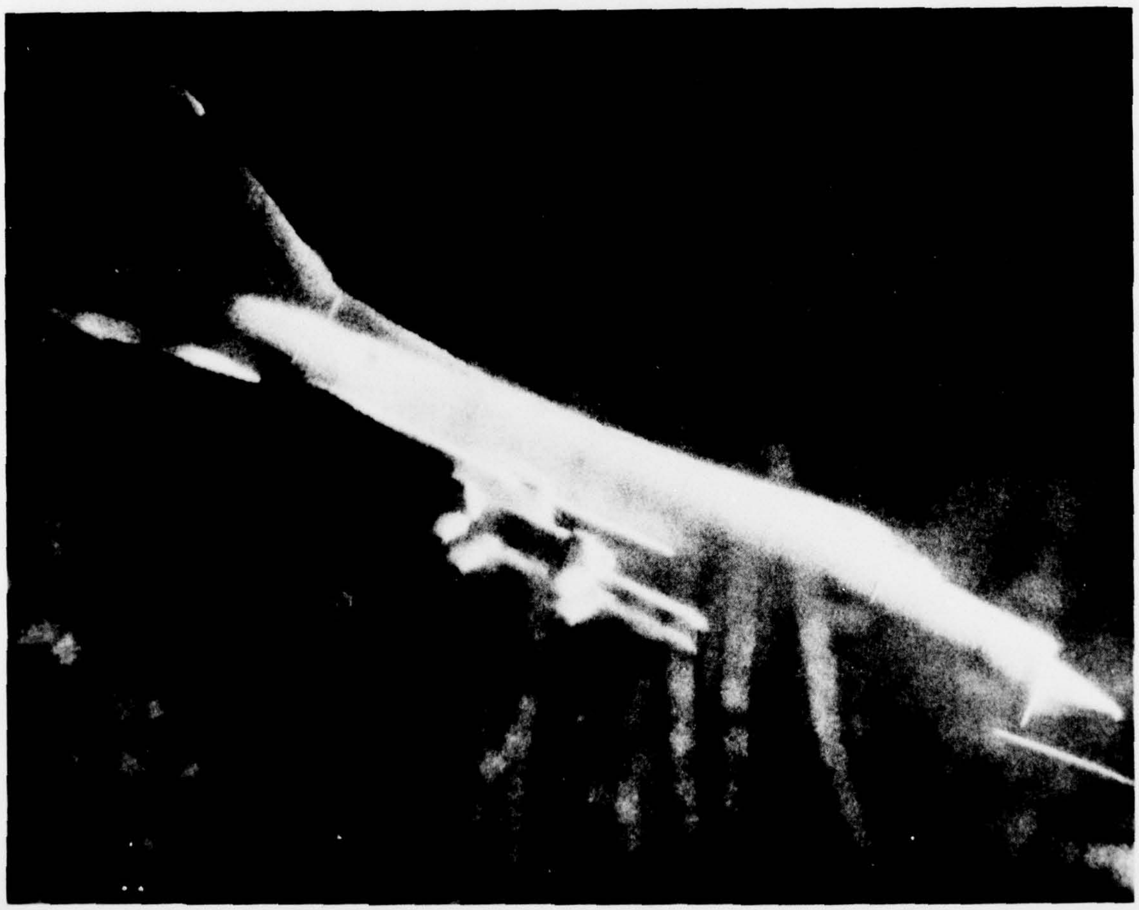

Figure 10. Holographic Image

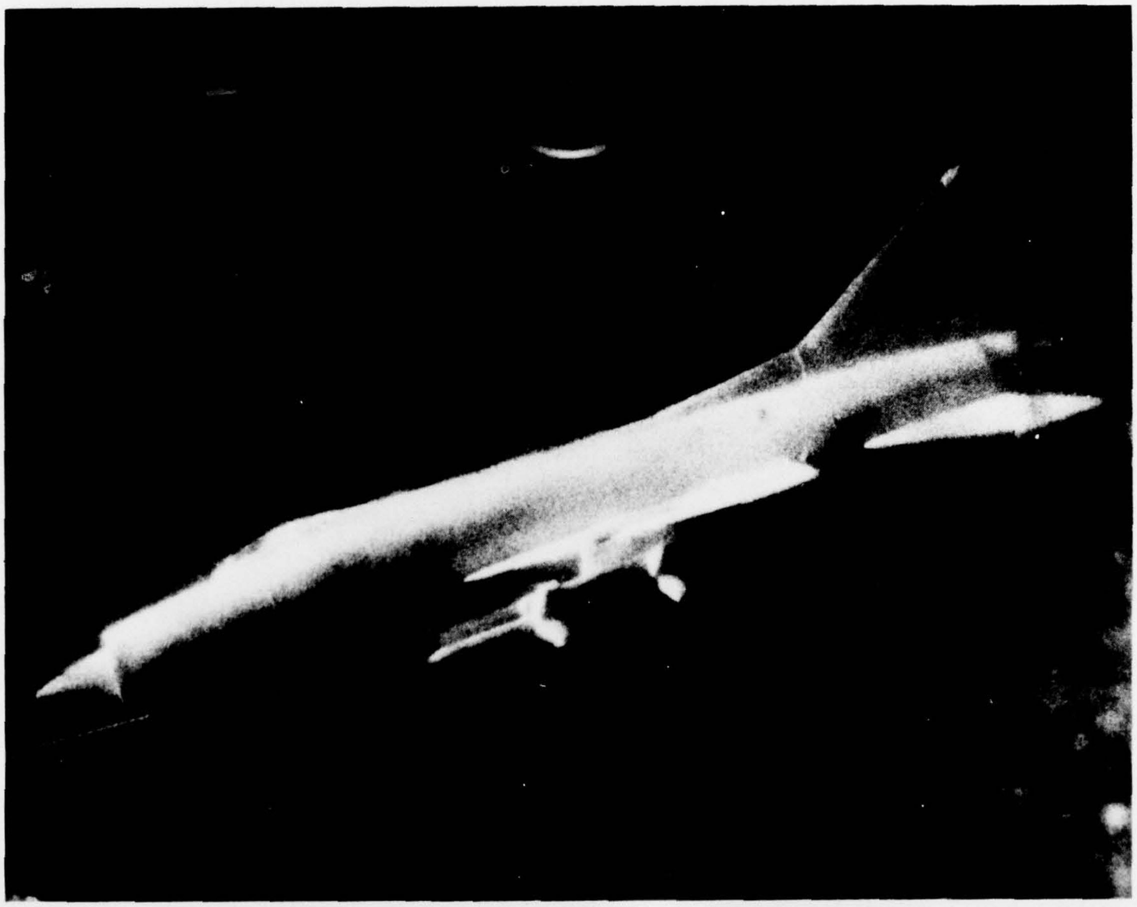

Figure 11. Holographic Image

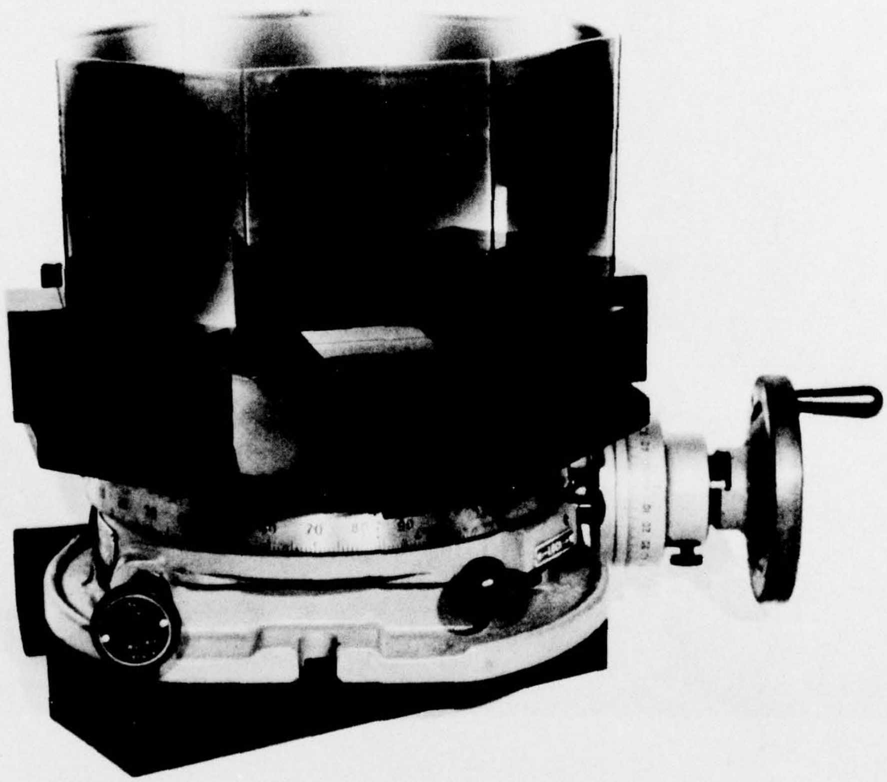

Figure 12. Alternate Film Configuration

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